

Atty. Docket No. PPW06-563DS
Serial No: 10/676,645

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Remarks

Applicant and his representatives wish to thank Examiner Nadav for the careful consideration of the Amendment filed September 14, 2006 and the clear explanations in the final Office Action dated November 9, 2006.

Claim 1 has been amended to remove a redundant term from the claim and improve the clarity of the claim language. Therefore, no new matter is introduced by the present Amendment, and since the amended claim terminology has already been considered by the USPTO, no new issues are believed to be introduced. Claims 1-5, 8, 22-24, 27-32 and 34-35 are active in this application.

The present invention relates to a semiconductor device comprising:

- a) a via within an insulation layer over a semiconductor substrate;
- b) a barrier metal layer on a surface of the via;
- c) a metal line in the via over the barrier metal layer;
- d) a pad in a predetermined region of the metal line; and
- e) an alloy layer on an upper surface of the metal line, wherein a top surface of the alloy layer is coplanar with or lower than a top surface of the insulation layer, and the alloy layer comprises a reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C. (see Claim 1 above).

The cited references do not disclose or suggest, alone or taken together, a semiconductor device including an alloy layer on an upper surface of a metal line, comprising a reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C., where the alloy layer has a top surface that is coplanar with or lower than a top surface of the insulation layer. Thus, the present claims are patentable over the cited references.

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The Rejection of Claims 1-5, 23, 24, 27-32 and 34-35 under 35 U.S.C. § 102(c) or 35 U.S.C. § 103(a)

The rejection of Claims 1-5, 23, 24, 27-32 and 34-35 under 35 U.S.C. 102(c) as being anticipated by or, in the alternative, 35 U.S.C. 103(a) as obvious over Matsubara (U.S. 6,890,852) is respectfully traversed.

Matsubara discloses a layer of copper buried wiring 8 comprising a copper thick film 10 and a copper thin film 9 which maybe made of pure copper or copper alloys (col. 10, ll. 20-22, and Fig. 1). Matsubara does not disclose a semiconductor device including an alloy layer on an upper surface of a metal line, comprising a reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C. As a result, Matsubara does not anticipate the present Claims 1-5, 23, 26-28 and 30. Thus, the rejection under 35 U.S.C. § 102(e) is not sustainable and should be withdrawn.

The reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C as recited in the present claims does not constitute a "product by process". No process step is recited in the claims. As is known in the art, material can be characterized as a reaction product without requiring that the process of reacting be performed. For example, a claim that recites "a reaction product of a proton and a hydroxide ion" reads on water, and does not require one to form it by reacting a proton and a hydroxide ion. One may not know the exact chemical formula or structure of a material such as an alloy. However, one can characterize that alloy as the reaction product of two (or more) components, without specifying the process in which the reaction product is formed. An oxide or nitride of silicon or metal may be characterized as a reaction product of oxygen or nitrogen and silicon or metal, but it is still a material, and not necessarily a product of a particular process.

Grammatically, there is no verb in the recited limitation. It appears that language such as "formed by reacting [A and B]" may be read into the claims, when such language is not present. Reaction product is a noun and cannot be read as a verb. Therefore, the reaction product recited in the present claims is not a "product by process."

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Rather, the claims clearly recite the structure and composition of the claimed device. The structure comprises a via, a barrier metal layer, a metal line, a pad, and an alloy layer. The composition of the alloy layer comprises a reaction product of the metal line and a low melting point metal. Therefore, the reaction product recited in the present claims is entitled to consideration as a structural and compositional limitation. As a result, the present Claims 1-5, 23, 26-28 and 30 are patentable over Matsubara. Thus, the rejection under 35 U.S.C. § 103(a) is not sustainable and should be withdrawn.

The Rejection of Claims 5, 8, 21-22, and 31 under 35 U.S.C. § 103(a)

The rejection of Claims 5, 8, 21-22, and 31 under 35 U.S.C. § 103(a) as being unpatentable over Matsubara in view of Liu et al. (US 6,638,867, hereinafter "Liu") is respectfully traversed.

As discussed above, Matsubara fails to teach, disclose or suggest an alloy layer on an upper surface of a metal line, comprising a reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C (see Claim 1 above). Liu fails to cure the deficiencies of Matsubara with regard to Claim 1.

Liu discloses a bonding pad 60 that includes an aluminum alloy bonding pad segment 54 in a shallow interconnection line 40 (see col. 6, ll. 16-27, and FIGS. 6C-6D) and an aluminum conductive layer 58 over the bonding pad segment 54 (see col. 6, ll. 34-42, and FIG. 6C). Liu further discloses that the conductive layer 58 over the bonding pad segment 54 can alternatively consist of aluminum alloy, tungsten, copper, or a copper alloy (see col. 6, ll. 35-40). Aluminum has a melting point below 1000°C., and as a result, the aluminum alloy conductive layer 58 on bonding pad segment 54 could, in theory, be the claimed alloy. However, Liu does not appear to teach or disclose that the non-aluminum metal in the aluminum alloy is a component of the metal in bonding pad segment 54 (see col. 6, ll. 34-40). Similarly, the copper alloy alternative for conductive layer 58 could be the claimed alloy, but there is no indication in Liu that the copper alloy is an alloy of copper and aluminum, aluminum being a component of bonding pad segment

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54 (see col. 6, ll. 34-40). Therefore, Liu does not disclose an alloy layer comprising the reaction product of a low melting point metal (i.e., having a melting point less than or equal to 1000°C) and a metal line, assuming for the sake of argument that bonding pad segment 54 constitutes a metal line.

On the other hand, if one selects aluminum or aluminum alloy for conductive layer 58 and a different metal or alloy for bonding segment 54, bonding pad segment 54 and conductive layer 58 could, in theory, form the claimed alloy. However, it appears that any such alloy would have a top surface that would not be coplanar with or lower than a top surface of the insulation layer, as recited in Claim 1. In addition, the bonding pad 60 disclosed by Liu includes shallow trench 40 that only partially penetrates insulative layer 134 (see col. 5, ll. 55-64, and FIG. 5A). Therefore, the metal feature 54 in shallow trench 40 is not in a via (see FIGS. 6A-6D). Thus, the bonding pad 60 disclosed by Liu does not cure the deficiencies of Matsubara with regard to the present Claim 1.

Liu does disclose a metal feature 50 in a via (col. 6, ll. 16-24). However, it is not included in the structure of bonding pad 60, and no metal or metal alloy is on an upper surface thereof. Furthermore, Liu does not disclose a semiconductor device including an alloy layer on an upper surface of a metal line, comprising a reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C. Therefore, Liu does not cure the deficiencies of Matsubara with regard to the present Claim 1.

As a result, Claim 1 (and all claims dependent therefrom, including Claims 5, 8, 21-22, 31 and 34) are patentable over Matsubara in view of Liu, the combination of which fails to teach, disclose or suggest an alloy layer on an upper surface of a metal line, comprising a reaction product of the metal line and a low melting point metal having a melting point less than or equal to 1000°C. Consequently, the rejection of Claims 5, 8, 21-22, and 31 under 35 U.S.C. § 103(a) should be withdrawn.

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Conclusions

In view of the above amendments and remarks, all bases for objection and rejection are overcome, and the application is in condition for allowance. Early notice to that effect is earnestly requested.

If it is deemed helpful or beneficial to the efficient prosecution of the present application, the Examiner is invited to contact Applicant's undersigned representative by telephone.

Respectfully submitted,

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